Special Feature 2

Leveraging the Strengths of Diverse Businesses to Adapt to Changes and Seek Sustainable Growth

Changes in customer needs and advances in technology have been proceeding at an increasing pace. There has also been lingering uncertainty about political and economic prospects. Amid this environment, Toyota Industries believes that engaging in multiple businesses with different strengths, as opposed to focusing solely on a specific business, will allow us to adapt to changes and achieve sustainable growth through complementary collaboration among these businesses.

This Special Feature presents some of our initiatives to promote sustainable growth by leveraging the strengths of our diverse businesses.

History of Business Expansion to Date

After conducting a great deal of research, founder Sakichi Toyoda invented the Type G automatic loom with an aspiration to “contribute to society through *monozukuri* (manufacturing).” Toyota Industries, founded to manufacture and sell the loom, had concentrated on expanding this original business but started seeking business diversification during the recession in the early 1950s.

At that time, the growing automobile industry in Japan was generating new needs. To capture these needs, we first branched out into the engine and vehicle assembly businesses by utilizing foundry and other technologies accumulated in the textile machinery field. Then we started developing and manufacturing car air-conditioning compressors. As labor shortages prompted a rise in the need for streamlining cargo handling, we directed our attention to lift trucks that have a number of components similar to automobiles such as an engine and launched development in this field. Moreover, capitalizing on our technology and know-how accumulated in the development and in-house production of electronic components for lift trucks, we entered the electronics business, offering electronics products also for automobiles.

In this way, we have constantly taken on the challenge of creating new value based on our own strengths and achieved continued growth, always upholding the philosophy of “contributing to society” since our founding.

Efforts to Deepen Collaboration among Businesses to Generate Ideas

Previously, business divisions of Toyota Industries had made development efforts individually, and in some cases, had not been able to fully leverage the necessary technical information or know-how and knowledge accumulated in other divisions. In recent years, the R&D Headquarters, an organization responsible for promoting research and development, has been assuming the role of ensuring horizontal alignment and promoting collaboration among the business divisions.

As these business divisions face similar technical issues and possess many common elemental technologies, we have been devising effective ways to generate synergies among them by collecting, disseminating and sharing information and providing opportunities for technical exchange.

We believe that these day-to-day efforts have helped us upgrade and increase the efficiency of our development activities.

For information gathering, we provide various forms of support. Examples include issuing *Toyota Industries Technical Review*, a magazine on technical information related to product development and *monozukuri*; disseminating information on changes in the R&D environment, including economic conditions in each country and the trends in the materials handling equipment and automobile industries; and presenting examples of companies having technological excellence. As opportunities for technical exchange, we hold Company-wide technology exhibitions of products and production engineering examples of each business division and meetings of the Council of Heads of Engineering Departments as a place for heads of the engineering departments of each business division to exchange information. Through these opportunities, we back up efforts to share and utilize technologies within Toyota Industries.

Company-wide technology exhibition (December 2019)

Toyota Industries Technical Review

Web
Link to *Technical Review* (in Japanese).

Example Outcome of Interdivisional Collaboration

1 Development of Hydrogen Circulation Pump and Inverter for Fuel Cell Vehicles — Compressor, Electronics

Kazuho Sato

Project leader
FC Project
Compressor Division
(As of March 31, 2020)

Background of Development

Toyota Industries’ hydrogen circulation pump and control inverter are fitted in a fuel cell vehicle (FCV) of Toyota Motor Corporation (TMC), which only emits water when driven and greatly contributes to a reduction of CO_2 emissions. As an FCV runs on electricity generated through a chemical reaction of hydrogen and oxygen, it significantly differs in structure from an internal-combustion vehicle. With a pool of compression technology accumulated in the Car Air-Conditioning Compressor Business and motor, inverter and other elemental technologies, however, we had faith in our ability to create a hydrogen circulation pump and inverter, two of the key components of an FCV critical to its driving performance. Applying these technologies, we launched development of the two components and succeeded in mass production.

Utilization of Existing Technologies

Hydrogen circulation pump

Developed by the Compressor Division

Efficiently circulates unreacted hydrogen and water generated in the electricity generation process.

Successfully developed a new, low-cost hydrogen circulation pump that is highly efficient, more compact and lighter weight by applying compression, motor and production engineering technologies accumulated in the car air-conditioning compressor field.

Inverter

Developed by the Electronics Division

Performs drive control of the pump with a minimum amount of electricity.

Developed a highly efficient inverter for a hydrogen circulation pump at a low cost by applying inverter engineering technologies accumulated in the electric car air-conditioning compressor field.

Control software

Developed by the Compressor Division

Quickly developed a high-quality control software program by applying software programs for electric car air-conditioning compressors.

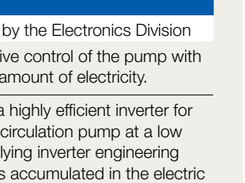
Completing a Hydrogen Circulation Pump by Overcoming Major Development-Related Challenges through Close Interdivisional Collaboration

We received various requests from TMC as it underwent the process of trial and error for the development of an FCV. One of them, in particular, related to the need to ensure smooth start-up and operation of the vehicle in sub-zero temperatures. In response, the circulation pump and inverter development teams worked together and improved the pump's startability and controllability. They also had repeated discussions from various perspectives for the alignment of work on the activation of an inverter at high temperatures.

The previous collaboration between the Compressor Division and Electronics Division in developing an electric compressor enabled us to quickly overcome the challenges in the new field. These divisions smoothly forged ahead with the development of respective products while mutually taking into account the impact of their own product on the other's product. This led to development activities that focus on overall optimization, transcending individual products. Other benefits included less time spent on discussion with the customer and increased efficiency in project flow.

We successfully developed products that generate new added value by bringing together and harmonizing elemental technologies cultivated in each business division.

Toward car electrification, the development of diverse products will become increasingly important in the future. We intend to leverage our advanced collaborative structure to provide new products through swift development efforts at a high level.



Example Outcome of Interdivisional Collaboration

2 Development of a Diesel Hybrid System for Construction Machinery

Materials Handling Equipment | R&D Headquarters | Engine | Electronics

Kenichi Katae

General Manager
Engineering Dept. No. 2
R&D Headquarters
(As of March 31, 2020)

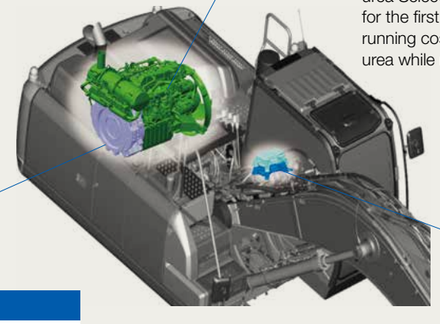
Background of Development

Since going into effect in 1991, the exhaust gas regulations for construction machinery have become progressively more stringent, and energy-saving needs have been also growing considerably. Against this backdrop, a leading construction machinery manufacturer has been promoting the development of environment-friendly hybrid excavators. We became the manufacturer's first choice as its partner because we had already had experience in developing hybrid systems, with Toyota Material Handling Japan initiating sales of a hybrid lift truck in 2010. The idea was to apply technologies we have cultivated in the electric lift truck field and in the Electronics Business to a hybrid system for construction machinery. Multiple business divisions of Toyota Industries accordingly started collaborating and developing key components, including an engine and a motor.

Fruits of Collaborative Development

Diesel hybrid system for construction machinery

Offers a 40% better fuel efficiency while maintaining high power performance.



Diesel engine Developed by the Engine Division

Satisfied exhaust gas regulations without using a urea Selective Catalytic Reduction (SCR)*1 system for the first time in the world*2 and achieved lower running costs by eliminating the need for refilling urea while maintaining durability.

Equipped in the ZH200-6 hybrid excavator of Hitachi Construction Machinery Co., Ltd.

Motor

Developed by the Engineering Dept. No. 2, R&D Headquarters

Offers high output and high efficiencies through an engine with a built-in motor, which can be fitted into the conventional engine space.

PCU (controlling motor's rotational speed)

Developed by the Electronics Division

Is based on a compact and highly efficient PCU for hybrid vehicles and offers improved cooling performance and vibration resistance matched to construction machinery.

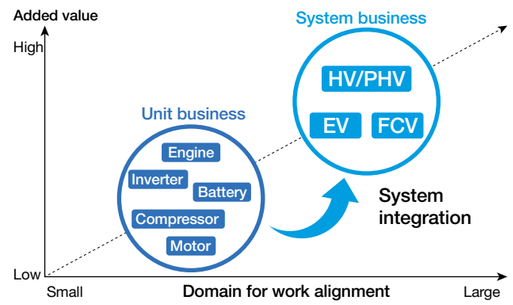
*1: Means to convert NOx
*2: Survey by Toyota Industries Corporation

Realizing a Hybrid System for Construction Machinery by Integrating Highly Functional Components

The most crucial challenge was how to realize an optimum system for construction machinery used in a considerably harsher environment than automobiles. To overcome this challenge, the Engineering Department No. 2 of the R&D Headquarters conceived the optimum design of the overall system, and each business division embarked on the development of an optimum component using the design as a starting point.

Specifically, we had to install components of the hybrid system, including an engine, motor and power control unit (PCU), into the conventional engine space. To accommodate more components, we needed to reduce the overall size, and at the same time, had to ensure the level of performance required for construction machinery. Taking on a challenge we had never faced before, the relevant business divisions joined forces and used their ingenuity to find a solution, which led to quickly developing a high-quality system.

Furthermore, we believe that already having a lift truck as a finished product in our lineup enabled us to take a holistic view in developing a hybrid system for construction machinery that is mechanistically similar to lift trucks. The result was a system that has realized a 40% higher fuel efficiency than conventional internal-combustion excavators, while maintaining the equivalent level of power performance.



HV/PHV: Motor, inverter, battery and engine
EV : Motor, inverter and battery
FCV : Motor, inverter, battery, oxygen-supplying air compressor and hydrogen circulation pump

Toyota Industries has a number of core technologies required in electrified products, such as hybrid vehicles (HV), plug-in hybrid vehicles (PHV), electric vehicles (EV) and FCVs, which are expected to become more diversified in the future. Going ahead, we intend to respond to electrification both in the materials handling equipment and automobile fields and swiftly deliver the required products to the world by combining components from these two fields and offering them as an integrated system.